Description

A METHOD FOR THE PROTECTION SWITCHING OF TRANSMISSION DEVICES IN RING-TYPE ARCHITECTURES CARRYING MPLS PACKETS

The invention relates to a method according to the preamble of patent claim 1.

A method for the protection switching of transmission devices in ring-type architectures is already known from German patent application DE 197 039 92.8.

This known method relates to transmission devices via which information is conducted in accordance with an asynchronous transfer mode (ATM). In this arrangement, transmission devices for the bidirectional transmission of information is/are provided in which two switching devices acting as terminal stations are connected to one another via a multiplicity of operating links and one protection link. The two terminal stations in each case contain monitoring devices for detecting transmission disturbances. A switching system, which can be controlled by a monitoring device, connects a receiving device to the operating link in a first switching state and to the protection link in a second switching state.

The disadvantageous factor of this known method is that it relates exclusively to ATM transmission devices. In the Internet, information is supplied to the receiving subscriber via a multiplicity of network nodes which can be constructed as routers. Between the routers, MPLS networks can be arranged. However, there is no mention whatsoever of MPLS networks in the known method.

The invention is based on the object of developing a method of the type initially mentioned in such a manner that information which is transmitted in accordance

with an Internet protocol can be transmitted with great reliability over a multiplicity of network nodes.

The invention is achieved, on the basis of the features specified in the preamble of patent claim 1, by its characterizing features.

The advantageous factor in the invention is, in particular, that a multiplicity of protection links share a jointly reserved transmission capacity.

Advantageous further developments of the invention are specified in the subclaims.

In the text which follows, the invention will be explained in more detail with reference to an exemplary embodiment.

In the figures:

Figure 1 shows an MPLS network linked in to the Internet,

Figure 2 shows a configuration for the bidirectional transmission of ATM cells in a linear 1:1 structure,

Figure 3 shows a ring-shaped configuration in which the method according to the invention is run,

Figure 4 shows the method according to the invention in the case of a simple fault,

Figure 5 shows the method according to the invention in the case of a double fault.

Figure 1 shows by way of example how information coming from a subscriber TLN1 is supplied to a subscriber

TLN2. The transmitting subscriber TLN1 is connected to the Internet network IP through which the information is conducted in accordance with an Internet protocol such as, e.g., the IP protocol.

This protocol is not a connection-oriented protocol. The Internet network IP exhibits a multiplicity of routers R which can be intermeshed with one another. The receiving subscriber TLN2 is connected to a further Internet network IP. Between the two Internet networks IP, an MPLS (Multiprotocol Packet Label Switching) network is inserted through which information is switched through in a connection-oriented manner in the form of MPLS packets. This network exhibits a multiplicity of mutually intermeshed routers. In an MPLS network, these can be so-called label switched routers (LSR). One of the routers is designated as transmitting device W and another one is designated as receiving device E.

MPLS packets in each case have a header (packet header) and an information section. The header is used for accommodating connection information whereas the information section is used for accommodating user information. The user information used is IP packets. The connection information contained in the header is arranged as MPLS connection number. However, this only has validity in the MPLS network. When thus an IP packet from the Internet network IP penetrates into the MPLS network, the header valid in the MPLS network is appended to it. This contains all connection information which predetermines the path of the MPLS packet in the MPLS network. If the MPLS packet leaves the MPLS network, the header is removed again and the IP packet is routed further as determined by the IP protocol in the Internet network IP following it.

Figure 2 shows by way of example two nodes of an MPLS network in a linear configuration which are in each

case arranged as switching device W, E. This is a 1:1 structure. In the present exemplary embodiment, it is assumed that these switching devices are MPLS cross-connect switching or label switched routers. Using switching devices of such a construction, however, does not signify a restriction of the invention and other switching devices such as, e.g., ATM switching devices can similarly be used. In Figure 2, MPLS (Multiprotocol Label Switched) packets are then to be transmitted from the label switched router W to the label switched router E.

In Figure 2, a case of bidirectional transmission is shown. However, the transmission of MPLS packets in the MPLS network is defined as being unidirectional. Accordingly, a total of two "connections" (one for the forward direction and one for the reverse direction) must be set up for the forward and reverse transmission of MPLS packets, belonging to a connection WT, between the label switched router W and the label switched router E in the case of bidirectional transmission. A "connection" in the MPLS network is called a Label Switched Path (LSP).

The label switched routers W, E are connected to one another via operating links (WORKING ENTITY), which according to the present exemplary embodiment are to be configured as a single operating link WE_1, and one protection link PE (PROTECTION ENTITY). Furthermore, switching systems S_0, S_1 (BRIDGE) are shown via which the incoming MPLS packets are optionally transmitted toward the label switched router E via the operating link WE_1 or the protection link PE.

Furthermore, Figure 2 shows selection devices SN, the task of which is to supply the MPLS packets transmitted via the operating link WE_1 to the output of the label switched router E. The selection devices SN are constructed as switching network. The switching network

SN is contained both in the label switched router W and in the label switched router E.

Furthermore, monitoring devices $ÜE_0$, $ÜE_1$ (PROTECTION DOMAIN SINK, PROTECTION DOMAIN SOURCE) which monitor the state or the quality of the MPLS packets transmitted via the operating link WE_1 are shown in the two label switched routers W, E. For example, the MPLS packets of the connection with the number 1 WT_1, before they are transmitted via the operating link WE_1 toward the label switched router E, are provided with control information in the monitoring device $ÜE_1$ of the label switched router W, which control information is extracted and checked by the monitoring device $ÜE_1$ of the receiving label switched router E. Using this control information, it is then possible to determine whether the transmission of the MPLS packets has been correct or not. In particular, a total failure (SIGNAL FAIL FOR WORKING ENTITY) of the operating link WE_1 can be determined here. Similarly, degradations in the transmission quality (SIGNAL DEGRADE) however can also be determined by using known methods.

The monitoring device $ÜE_1$ terminate the operating link WE_1 at both ends. Other monitoring devices $ÜE_0$ are arranged at both ends of the protection link PE. In the case of a fault, this is to be used as transmission link for the operating link WE_1 taken out of operation. Furthermore, protection switching protocols ES are transmitted via this link so that the integrity of the protection link has top priority.

In each of the label switched routers W, E, central controllers, not shown in Figure 2, are also arranged. These contain in each case local and global priority tables. In the case of the former, status and priority of the local label switched router is stored whereas in the case of the latter, status and priority both of the local and of the remaining label switched routers are

stored. The introduction of the priorities has the result that when a number of protection switching requests occur at the same time, the link is specified which is to be protection-switched. Similarly, the protection switching requests are prioritized in the priority tables. Thus, for example, there is a high-priority request from a user. Since this protection switching request is assigned a high priority, it is thus controlled with preference. A protection switching request controlled by the operating link WE_1 will then be rejected in this case.

The central controllers of the label switched routers W, E exchange information in a protection switching protocol ES. This protocol is transmitted via the protection link PE and extracted by the associated monitoring device $ÜE_0$ from the respective receiving label switched router E, and supplied to the relevant central controller. Furthermore, the central controller ensures that the switching systems S_0 ,S_1 are appropriately controlled in the case of a fault.

In the protocol ES, information relating to the current states of the switching systems is stored. Furthermore, other information with respect to the protection switching request generated is also stored. The protocol is in each case exchanged between the two label switched routers when the protection switching request is generated. In a special embodiment of the invention, there is provision for the protocol ES to be additionally transmitted cyclically between the two label switched routers.

According to Figure 2, the MPLS packets are supplied to the label switched router E in the case of correct operation. The MPLS packets are to belong to the connection WT_1 in this case. The individual connections are distinguished by means of the logical MPLS connection number entered in the packet header.

In this (still correct) operating case, the switching systems S_0, S_1 of the label switched router W are switched in such a manner that the MPLS packets are directly supplied to the monitoring device $ÜE_1$. In the latter, the control information already discussed is applied to the receiving label switched router E to the MPLS packets and they are supplied to the receiving label switched router E via the operating link WE_1 of the monitoring devices $ÜE_1$. At said label switched router E the accompanying control information is checked and, if appropriate, a fault case is determined. If the transmission has been correct, the MPLS packets are supplied to the switching network SN, where the MPLS connection information is evaluated and the MPLS packet is forwarded in accordance with this evaluation via the appropriate output of the switching network SN into the MPLS network.

The protection link PE can remain unused during this time. If necessary, however, it is also possible to supply special data (EXTRA TRAFFIC) to the switching device E during this time. In this case, the switching system S_0 of the switching device W assumes the positions 1 or 3. The special data are also transmitted in MPLS packets. The monitoring device $ÜE_0$ in the label switched router W applies control information to the MPLS packets in the same manner as has already been described in the case of those via the operating link WE_1. The link is monitored similarly. The special data used can be control data of a general type which can also be in the form of special traffic data.

The special data transmitted via the protection link can also be low-priority traffic which is only transmitted in the network when there are sufficient resources available. The low-priority traffic is then automatically displaced by high-priority traffic being protection-switched in this case. In this case, the

special data are not displaced in the protection switching case by switching the switching system S_0 in Figure 2, but by prioritizing the high-priority traffic with respect to the low-priority special data in each transmission device.

In the text which follows, it is now assumed that the operating link WE_1 has failed. This is determined by the monitoring device $ÜE_1$, associated with this operating link WE_1, of the receiving label switched router E. The protection switching request is then transmitted to the relevant central controller and is stored there in the local priority table and in the global priority table.

As determined by the priorities stored in the global priority table, it is then determined whether requests with higher priority are still present. This could be, for example, the switch-over request of the user already discussed (FORCED SWITCH FOR WORKING ENTITY). If there are no requests with higher priority present, the switching system S_1 of the label switched router E is driven into the remaining operating state, as shown in Figure 2. Thereafter, the protection switching protocol ES is then supplied to the label switched router W via the protection link PE. This protection switching protocol contains the information already discussed. The essential factor is that the local priority logic defines the arrangement of the information with respect to the protection switching request generated, and the global priority logic defines the position of the switching system S_0.

The monitoring device $ÜE_0$ of the label switched router W then takes over the protection switching protocol ES and supplies it to the central controller of the label switched router E. If here, too, no further requests with higher priority are present in the global priority table, the switching system S_1 is also correspondingly driven and set in this case. Furthermore, the switching

system S_0 of the label switched router W is also switched over. The new status of the two switching systems S_0, S_1 is acknowledged to the label switched router E via the protection switching protocol ES, and updated in the global priority table there. The MPLS packets of the connection WT_1 are then supplied to the label switched router E via the protection link PE.

In Figure 3 shows the ring configuration according to the invention. The switching devices are connected in such a manner in this case that the result is a closed ring. According to the present exemplary embodiment, this ring is to be configured from linear connection elements, as shown in Figure 2 (1:1 structure).

Accordingly, a multiplicity of label switched routers can be found in Figure 3. These are the label switched routers N_A, N_B, N_C and N_D. Two of these label switched routers in each case terminate transmission sections. Using the example of label switched routers N_A, N_D, these are the operating link WE_{A-D} and the protection link PE_{A-D}. In the same manner, the two label switched routers N_B, N_C terminate the connection elements WE_{C-B}, PE_{C-B}. It is known that the latter are protection links assigned in each case. According to Figure 3 (and also Figure 4, Figure 5), the operating links are emphasized by means of a thicker line, whereas the protection links are only identified by a thin line.

Furthermore, switching devices S_1, SN which are identical to the switching devices shown according to Figure 2 can be found in all label switched routers. To simplify understanding, a more detailed disclosure is not given here. In all label switched routers, central controllers with local and global priority tables are arranged which are not shown in greater detail here either. The operation has already been explained in greater detail in the case where a linear arrangement according to Figure 2 is used.

It will now be assumed that a connection WT_{A-D} is to be conducted via the ring between two subscriber terminals. In this arrangement, the MPLS packets belonging to this connection are supplied to the label switched router N_A and conducted via the respectively active operating link WE_{A-D} to the label switched router N_D, where the MPLS packets belonging to the connection WT_{A-D} leave the ring again.

In Figure 3, an arrow indicates the direction in which these MPLS packets enter the ring and leave it again. However, since this connection is a bidirectional connection, the MPLS packets belonging to the relevant reverse direction are conducted via the same connection elements. This means that the MPLS packets belonging to the reverse direction enter the ring via the label switched router N_D, are conducted via the connection WE_{A-D} to the label switched router N_A where they leave the ring again. For better clarity, however, only one direction will be illustrated in the text which follows. As a further embodiment of the invention, it is provided to arrange this configuration as a case of unidirectional transmission. This is easily possible since the transmission of MPLS packets is defined as being unidirectional in contrast to the transmission of ATM cells. However, this case of unidirectional transmission, too, requires a reverse direction and a protection switching protocol because the protection switching process must always be coordinated between transmitting and receiving end in the 1:1 architecture relevant in this case.

The same applies to the other connections WT_{C-B} and WT_{C-D} shown according to Figure 3. The MPLS packets belonging to the three connections WT_{A-D}, WT_{C-B} and WT_{C-D} shown here are transmitted via the respectively active operating links WE_{A-D}, WE_{C-B} and WE_{C-D}. The associated protection links PE_{A-D}, PE_{C-B} and PE_{C-D} initially remain untouched.

Figure 4 then shows how a fault in the ring is to be treated. This will be done using the example of the connection WT_{A-D}. It is thus assumed that the transmission section between the label switched routers N_A and N_D is affected by a fault. It is also assumed that this should be initially the only fault in the ring. The label switched router N_A is informed of the fault by exchanging the protection switching protocol ES over the protection link PE_{A-D}. As determined by the evaluation of the local and global priorities, the switching device S_1 of the label switched router N_A is now controlled into the remaining operating state. The MPLS packets belonging to the connection WE_{A-D} are then supplied via this protection link PE_{A-D} and via the label switched routers N_B and N_C to the label switched router N_D where they leave the ring.

According to the invention, a common transmission capacity is now reserved for the jointly used protection path for connection elements situated between two label switched routers. This is possible since it is assumed that only one connection element of the ring is faulty. For example, it would be possible to assign in each case 140 Mbit/sec to the connections WT_{A-D}, WT_{C-B} and WT_{C-D}. For the connection element situated between label switched routers N_A, N_B, 140 Mbit/sec would thus be assigned for all three protection links. This means that in the case of protection switching, 140 Mbit/s are only available to one operating link on the associated protection link. Similar considerations apply to the connection elements situated between the label switched routers N_B, N_C. 140 Mbit/s would have to be reserved here in the same manner and, in the case of protection switching, a transmission capacity of 140 Mbit/s is also available in its full extent to only one operating link on the associated protection link.

Such a procedure has the advantage, in particular, that, for each connection, fewer charges for transmission capacity must be registered ("shared protection"). It would be different in the case of "dedicated protection". The saving effect is most advantageous in the case where a connection is established between two adjacent label switched routers. This is the case, for example, for the connection WT_{A-D} between the label switched routers N_A, N_D. The saving effect is greatest here because the associated protection links must be conducted to the label switched router N_D via the two further label switched routers N_B, N_C. The same applies to the other connections WT_{C-D} and WT_{C-D} shown.

If the label switched router N_A is arranged as switching level of a higher hierarchy level (such as, e.g., a core network), the saving effect would be the lowest compared with a "dedicated protection" configuration. In this case, any traffic of the remaining label switched routers would have to be conducted via this higher-level label switched router N_A. A medium saving effect would be obtained if each of the label switched routers were to communicate with each label switched router in the sense of a complete intermeshing.

Special data of a general type as explained in conjunction with Figure 2 cannot be transmitted via the ring. In particular, these are the control data considered there. According to the invention, however, the special traffic data arranged as special data can be transmitted because of their own priority assigned to them.

Finally, a further fault case will be shown by way of example according to Figure 5. In this case, an additional fault case is to occur on the communication link WE_{C-B} in addition to a simple fault as shown in Figure 4. In this case, further protection switching

protocols are exchanged. In this case, however, both the operating link and the protection link are faulty. Due to the joint reservation of transmission capacity for protection links, connections which are not influenced by the fault would also be affected in the case of protection switching of both affected operating links to the respective protection link. In the present case, these are the connections WT_{C-D}. Since a switch-over would not bring any advantage in this case as the protection link is also faulty, no switch-over will thus be performed in the case of the occurrence of double faults.